Sound Velocity Profiles in the Gulf of the Farallones Compared to GDEM

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Introduction

The data examined is comprised of GDEM (Generalized Digital Environmental Model) data supplied by the Naval Oceanographic Office(NAVO) and NAVO cruise data from May 2001. The purpose of the cruise was to collect data that could be used for mine and antisubmarine warfare in coastal waters. This paper will compare the actual SVP(Sound Velocity Profile) data to GDEM data, note the differences and offer hypothesis as to why they differ.

Background

Shallow water surveys and models are becoming increasingly important as naval operations penetrate further into littoral waters. This particular study by NAVO is to look for trends in shallow water regions over time and space on a small scale. This paper points out the limitations of GDEM compared to actual SVP data, and the importance of better model resolution and predictions in hot spots of the world. GDEM is a good starting point for general acoustic detection models regarding mine hunting and antisubmarine warfare. However, during hostile operations the need for real-time SVP’s becomes critical for operational planning.

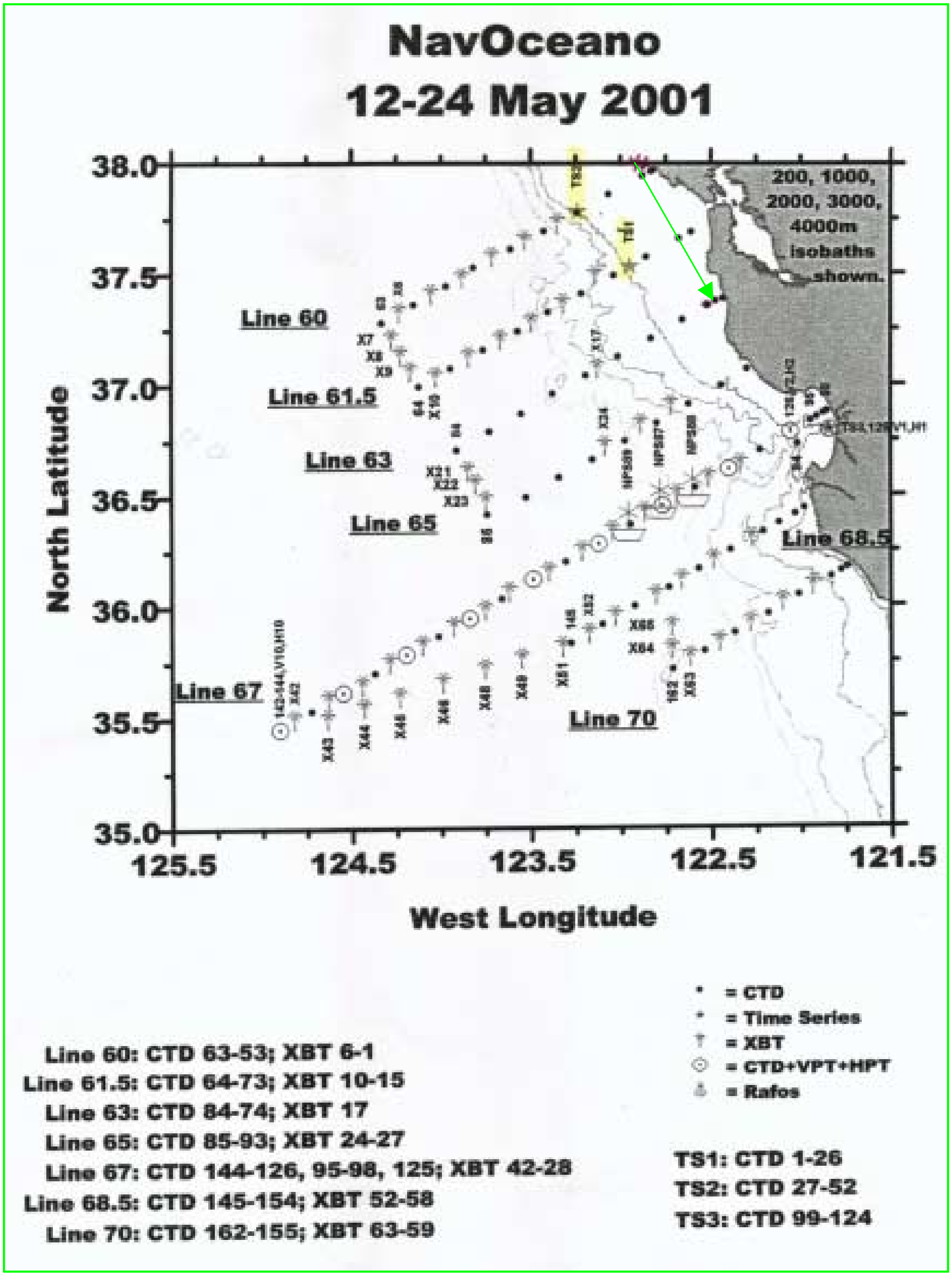


Figure 1: NAVO cruise with time series Stations 1 & 2 denoted by stars and spatial time series by green arrow.

Cruise Data

There are two sets of shallow water data taken as 26-hour time series, along with an extensive spatial survey. The time series consisted of lowering the CTD at the same location every hour for 26 hours. The first station was located at 37.5N 123W while the second was at 37.8N 123.2W(Figure 1). The spatial survey went southeast, beginning at 38N 122.8W and ended at 37.1N to 122.3W covering five and a half days.

GDEM Data

GDEM is a physical oceanographic synthetic environment. MOODS (Master Oceanographic Observation Data Set) is the primary input to GDEM. Global temperature and salinity data profiles from all available sources are also used to create GDEM. MOODS is evaluated using NIDAS (Naval Interactive Data Analysis System) to eliminate erroneous profiles before being used in GDEM. The global coverage of GDEM is categorized by grid resolution(Figure 2). Volatile areas of the globe require better resolution, hence ten and twenty arcminute grid spacing.

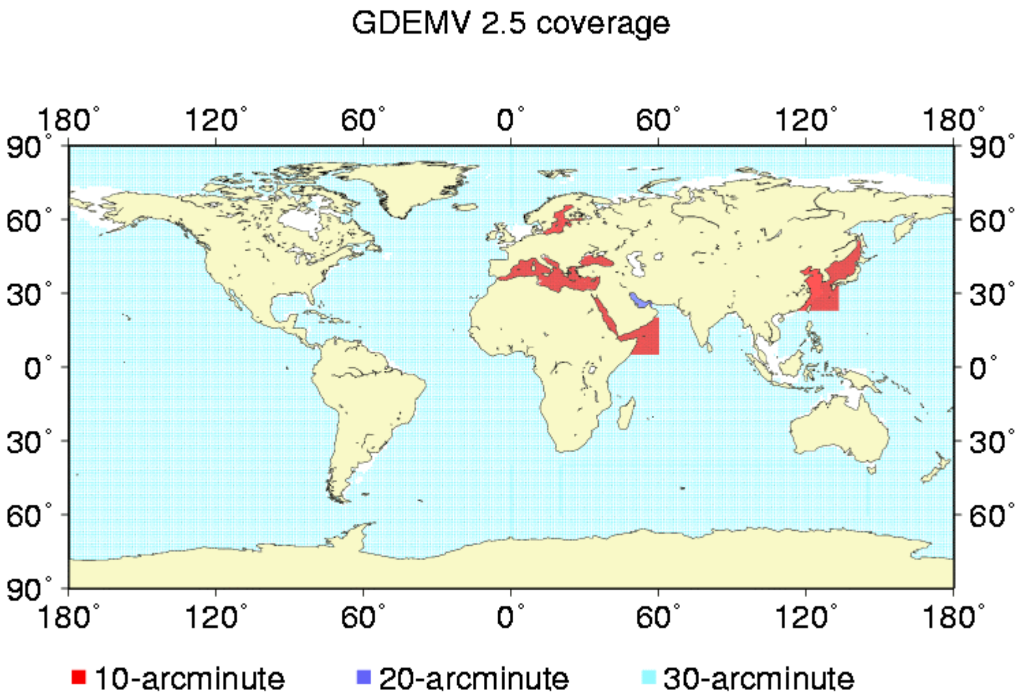
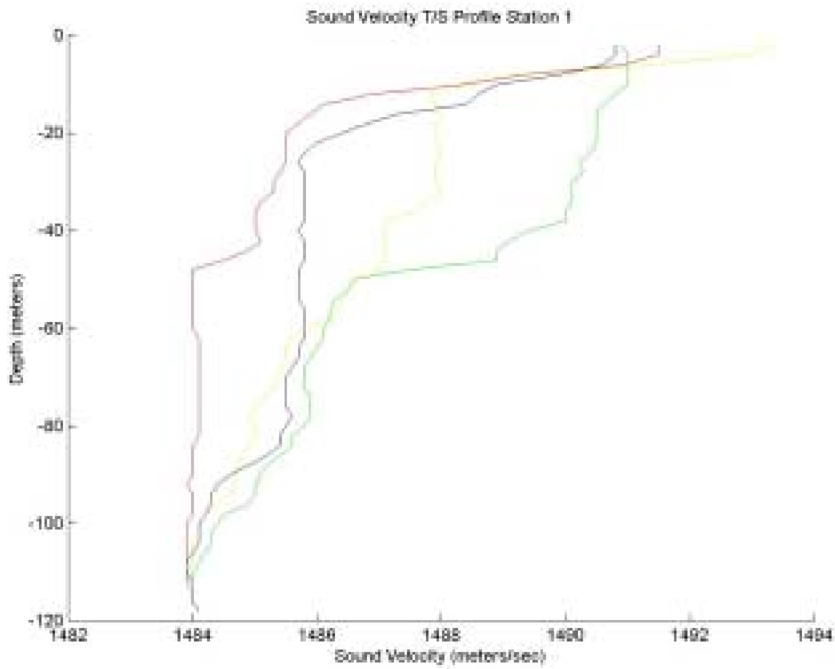


Figure 2: Global coverage of GDEM resolution

Analysis

The SVP profiles of Stations 1 & 2 show the diurnal shallowing and deepening of the mixed layer due to surface heating and cooling(Figure 3). Surface warming weakens mixing and shallows the mixed layer as in daytime or summer conditions. Surface cooling occurs at night or winter, deepening the mixed layer. The highest sound velocity does not correspond to the shallowest mixed layer since mixing is not instantaneous. Station 2 has a greater SVP variation below 100 meters and higher sound speeds at the surface. Stations 1 & 2 exhibit similar characteristics as expected.



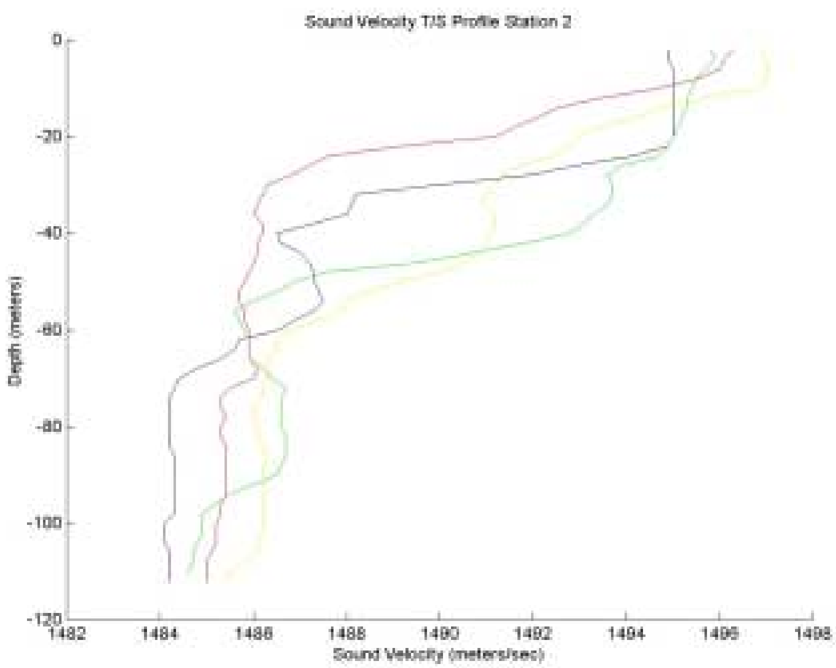


Figure 3: SVP time series for Stations 1 & 2. The four most significant profiles are shown. The shallowest and deepest mixed layers are red and green, respectively. The lowest and highest surface sound velocities are black and yellow respectively.

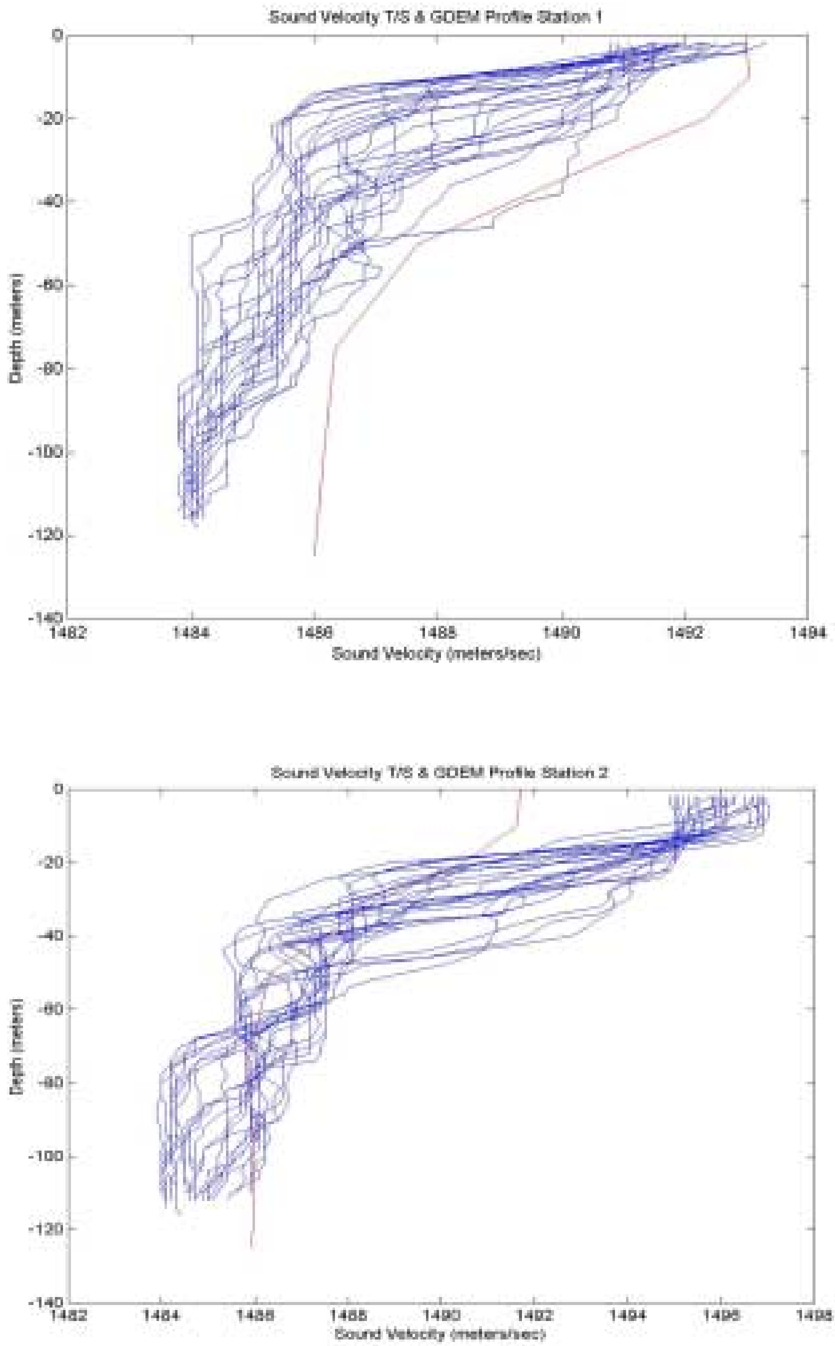


Figure 4: SVP 26-hour time series in blue and GDEM data in red. Station 1 (top) corresponds less than Station 2 (bottom) with respect to GDEM.

Station 1 had the greatest difference between GDEM and observed sound velocity profiles(Figure 4). GDEM is significantly different at all depths for Station 1, while it is generally correct for Station 2 below 20 meters. GDEM resolution is 0.5 degree for most of the globe, at which point data in that area is averaged to create SVP curves. GDEM is a climatology in that it represents a 70-year data mean. Single observations seldom match a mean value, as is the case here. Station 1 is on a GDEM data point where station 2 is slightly off. The base of the entrainment zone is deeper at station 2, greater than 20 meters.

Figure 5: High-resolution bathymetry chart with the spatial survey track in green.

The spatial survey was taken inshore of Stations 1 and 2, across the mouth of San Francisco Bay(Figure 5). The spatial survey has higher surface sound velocity variation and slightly higher 120-meter velocities(Figure 6). Outflow from San Francisco Bay may explain some of the differences compared to Stations 1 & 2.

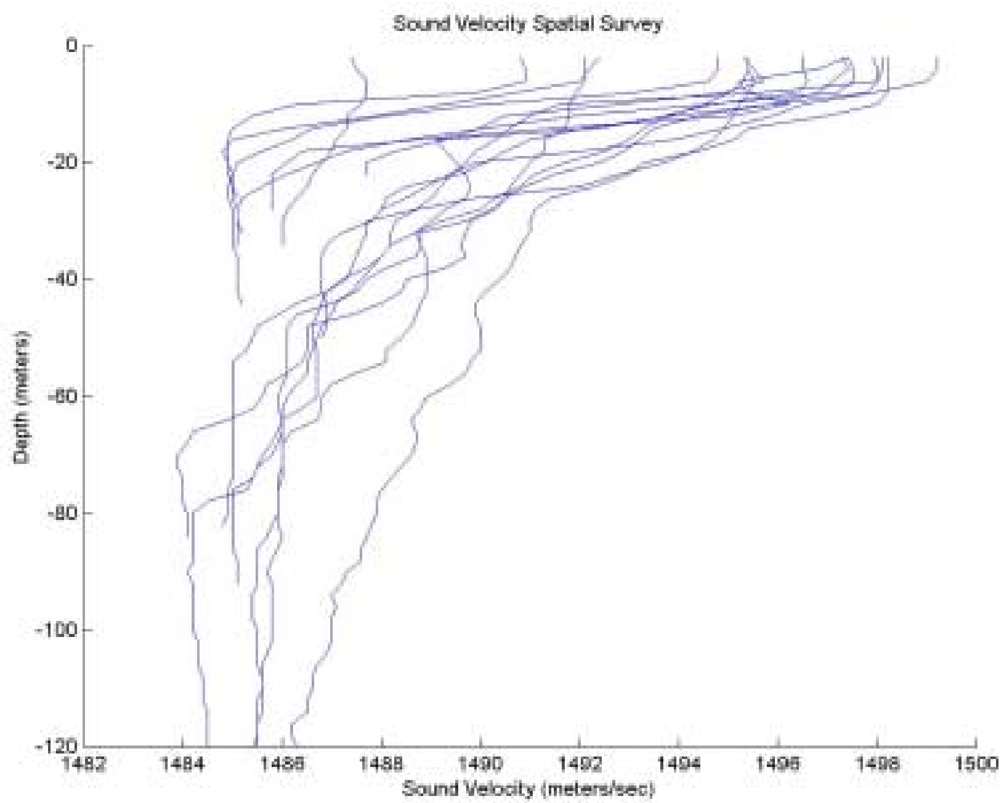


Figure 6: Spatial survey SVP’s.

Conclusions

The general characteristics of the NAVO cruise data are best examined using a mean SVP plot(Figure 7). The entrainment zone of station 2 had a greater variation of sound velocity due to the higher surface temperatures. All SVP’s have the same characteristic profile of mixed layer, entrainment zone, then thermocline. There was some surface sound speed variation, but all velocities were 1485 $\pm$ 1 m/s at 120 meters.

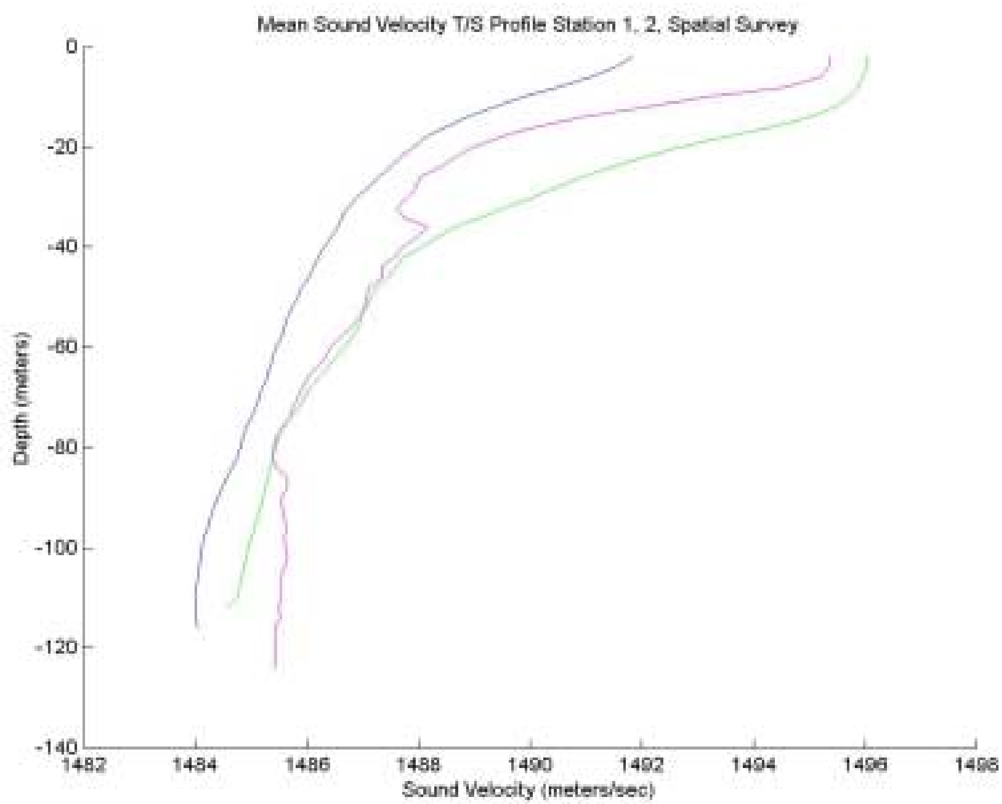


Figure 7: Mean SVP’s of Station 1(blue), Station 2(green), and spatial survey(magenta).

The variations of the NAVO cruise data are best examined utilizing the standard deviation plot(Figure 8). Stations 1 & 2 are similar, and have little variation at the surface and bottom. The greatest variation is at 25 meters where the mixed layer varies the most from diurnal effects. The spatial survey has the greatest variation at the surface and 18 meters, since it covered five and a half days and crossed the mouth of San Francisco Bay. The upper 45 meters contained the greatest standard deviation for all profiles.

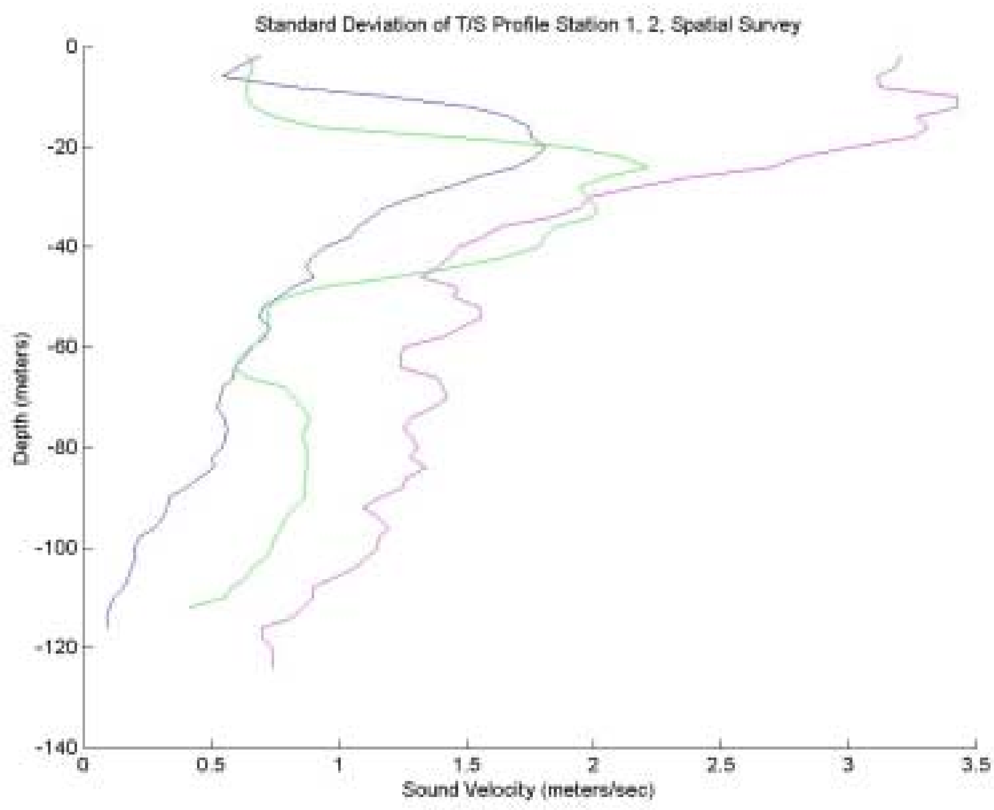


Figure 8: Standard deviation of Station 1(blue), Station 2(green), and spatial survey(magenta).

The initial intent of this project was to examine how the variations of SVP data would affect the output of the CASS/GRAB(Comprehensive Acoustic Simulation System/Gaussian Ray Bundle) Navy acoustic model. Then to examine if this variation was significant compared to GDEM data inputs. The Naval Postgraduate School has the MATLAB CASS/GRAB version, which is not user-friendly. After consulting with Chenwu Fan, an expert MATLAB programmer, his conclusion was that intimate source code knowledge was required to conduct the modifications needed.

The GUI(Graphical User Interface) CASS/GRAB version is operational at NAVO, however due to licensing issues it was unavailable. My recommendation would be to obtain the GUI CASS/GRAB version to evaluate the significance of actual versus GDEM SVP data.